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CORRELATION OF RESONANCE CHARGE EXCHANGE CROSS-SECTION DATA  
IN THE LOW-ENERGY RANGE

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During the course of a literature survey concerning resonance charge exchange, an unusual degree of agreement was noted between an extrapolation of the data reported by Kushnir, Palyukh, and Sena<sup>1</sup> and the data reported by Ziegler.<sup>2</sup> The data of Kushnir *et al.* are for ion-atom relative energies from 10 to 1000 ev, while the data of Ziegler are for a relative energy of about 1 ev.

Extrapolation of the data of Kushnir *et al.* was made in accordance with Holstein's theory,<sup>3</sup> which is a combination of time-dependent perturbation methods and classical orbit theory. The results of this theory may be discussed in terms of a

critical impact parameter  $b_c$ . For impact parameters less than  $b_c$ , the theory says the probability of charge exchange  $P$  is a rapidly oscillating function of  $b$  with extremes at 0 and 1 and an average value of  $\frac{1}{2}$ . For  $b > b_c$ ,  $P$  rapidly drops from  $\frac{1}{2}$  to zero with increasing  $b$ . Holstein gives the expression for  $P$  as a function of  $b$  and relative energy  $\epsilon$ . Setting  $P$  equal to  $\frac{1}{2}$ , he gets an equation for all the  $b$ 's where  $P$  passes through  $\frac{1}{2}$ . If attention is restricted to the largest  $b$ , which is a solution to this expression, we have  $b_c$  as a function of energy. If  $b_c$  is used to compute a cross section ( $\sigma = \pi b_c^2$ ), Holstein's theory gives

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FIG. 1. Charge exchange cross section for  $\text{Ar}^+$  in Ar. Curve is Eq. (1) fitted to data of Kushnir *et al.*

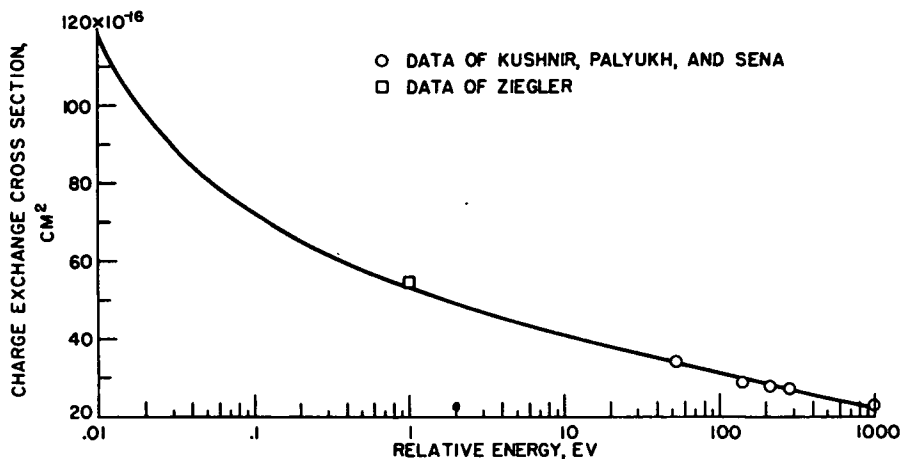
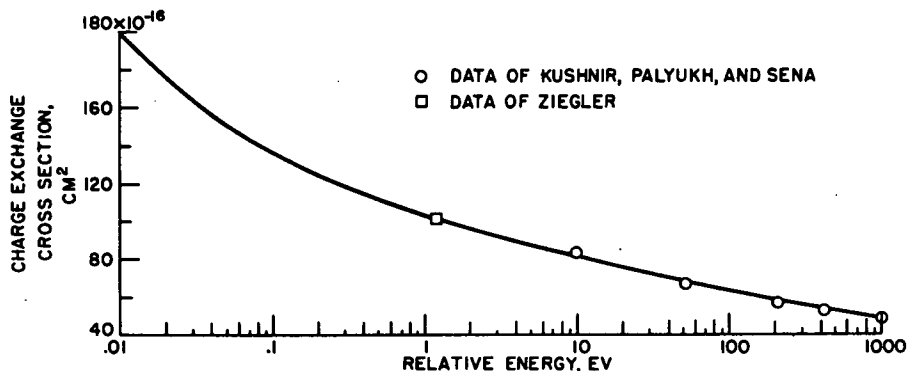


FIG. 2. Charge exchange cross section for  $\text{Xe}^+$  in Xe. Curve is Eq. (1) fitted to data of Kushnir *et al.*



a charge exchange cross-section energy relationship of the form,

$$\epsilon = K_1 \sigma^{1/2} \exp(-K_2 \sigma^{1/2}),$$

where  $K_1$  and  $K_2$  are functions of the interaction potential. Note that, for a given  $\epsilon$ ,  $\sigma$  is double valued. The lower  $\sigma$  value had no meaning as a cross section. It corresponds to one of the  $b$ 's less than  $b_c$  where the oscillating  $P$  passes through  $\frac{1}{2}$ . A curve of the form of the above equation was

fitted to the data of Kushnir *et al.* These curves (corrected for polarization<sup>3</sup>) are shown in Figs. 1 and 2 for Ar and Xe, respectively. The data of Ziegler are also shown in these figures.

The mobilities of Ar and Xe were computed according to Holstein<sup>3</sup> using the extrapolated cross-section curves of Figs. 1 and 2. The computed values of mobility are compared in Table I with experimental values reported by Biondi and Chanin.<sup>4</sup>

The agreement of the two sets of cross-section data with each other and with mobility data is unusually good when one considers the wide range of energy included in the correlation.

Table I. Mobility at 300°K.

	Mobility (cm <sup>2</sup> /volt-sec)	
	Biondi and Chanin <sup>a</sup> (experimental)	Extrapolation of Kushnir, Palyukh, and Sena data <sup>b</sup>
Ar	1.6	1.50
Xe	0.595	0.453

<sup>a</sup>See reference 4.

<sup>b</sup>See reference 1.

<sup>1</sup>R. M. Kushnir, B. M. Palyukh, and L. A. Sena, *Izvest. Akad. Nauk S.S.S.R.* **23**, 1007 (1959) [translation: *Bull. Acad. Sci. U.S.S.R., Phys. Ser.* **23**, 995 (1959)].

<sup>2</sup>B. Ziegler, *Z. Physik* **136**, 108 (1953).

<sup>3</sup>T. Holstein, *J. Phys. Chem.* **56**, 832 (1952).

<sup>4</sup>M. A. Biondi and L. M. Chanin, *Phys. Rev.* **94**, 910 (1954).